Accumulator Stacktail Cooling

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Stochastic Stacking

- van Der Meer solution:
  - Constant Flux: $\frac{\partial \Box}{\partial t} = \text{constant}$
  - Solution: $\frac{\partial \Box}{\partial E} = \frac{\Box}{E_d}$, where E_d characteristic of design $\Box = \Box_0 \exp\left[\frac{\Box(E \Box E_i)\Box}{E_d}\right]$
  - Exponential Density Distribution generated by Exponential Gain Distribution
  - Max Flux = $(W^2|\Box|E_d)/(f_0 p \ln(F_{max}/F_{min}))$
    - W bandwidth, F_{max} and F_{min} frequency range
    - f_0 beam revolution frequency, p beam momentum
    - $|\Box|$ phase slip factor
    - E_d characteristic gain slope

Stacktail Design Scenario

- Goal: 80 mA/hour peak stacking rate in Accumulator
  - x2 design margin above 40 mA/hour
- Accumulate for 30-60 minutes, transfer to Recycler
  - Optimize for maximum flux, not momentum density
  - Maximum stack size 50-60 mA to avoid significant falloff in stack rate
    - Consistent with current systems (~20% dropoff in rate from 20 mA to 60 mA)
- Change Bandwidth & E_d
  - 2-6 GHz
  - 9 MeV gain slope
  - Maximum flux ~ 102 mA/hour

Stacktail Reconfiguration (Option)

- Move positions of pickups and change electronics settings to change E_d while keeping 2-4 GHz band
  - 1 mm move on 2 tanks
  - 7 mm move on 1 tank
  - No M&S cost
  - Take advantage of increased flux?
- Target E_d ~ 18 MeV
- Maximum stacking rate 80 mA/hour
- Simulations sustain 60 mA/hour for 30 minutes
- Requires Recycler as final repository

Specifications

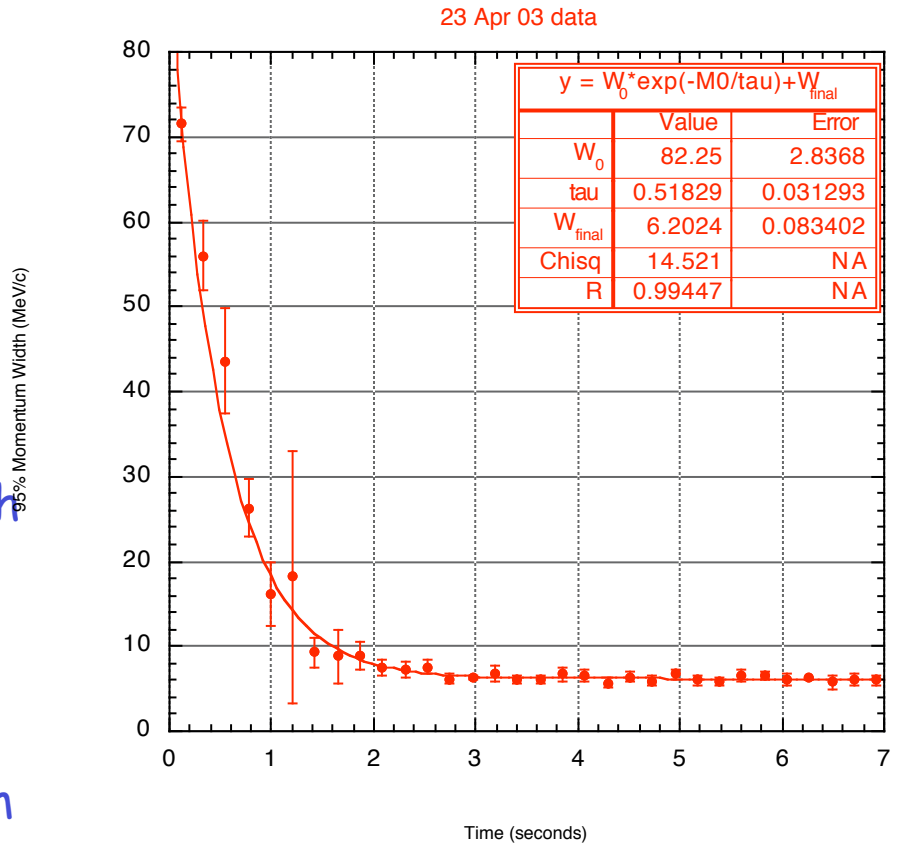
- Input:
  - 50 π transverse emittance
  - 6 MeV/c 95% momentum width
  - 2 second cycle time
- Output:
  - 30-60 minutes accumulation time
  - ~1 minutes extraction
  - Extract
    - 10 eV-sec
    - Transverse ~10 π

Current Debuncher Performance

- Large initial momentum
- Exponential decay time:
  - 0.5 sec
- @ 2 seconds:

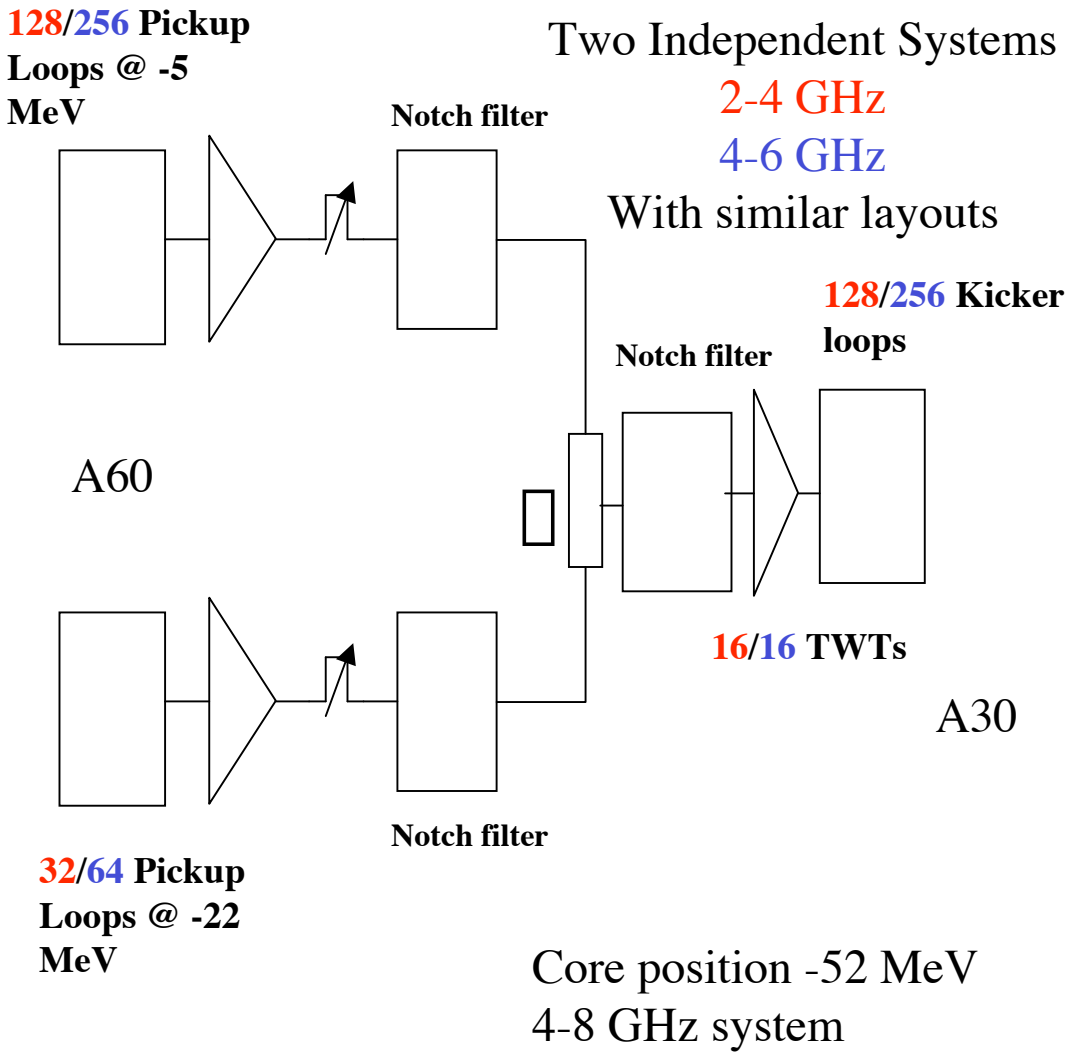
  7.9 ± 0.4 MeV/c

- Improvement to notch filter equalizers to:
  - Minimize asymptotic width
  - Minimize cooling time
- Improvement to MI bunch rotation
  - Minimize initial momentum spread



Design Decision

- 2-6 GHz total bandwidth in parallel systems
  - 2-4 GHz band
    - Equivalent to current stacktail
    - Utilize existing hardware
    - Replace $^1/_2$ system
  - 4-6 GHz band
    - New hardware
      - Pickup & Kicker loops
        - » New design?
      - Electronics
  - Layout similar for both systems

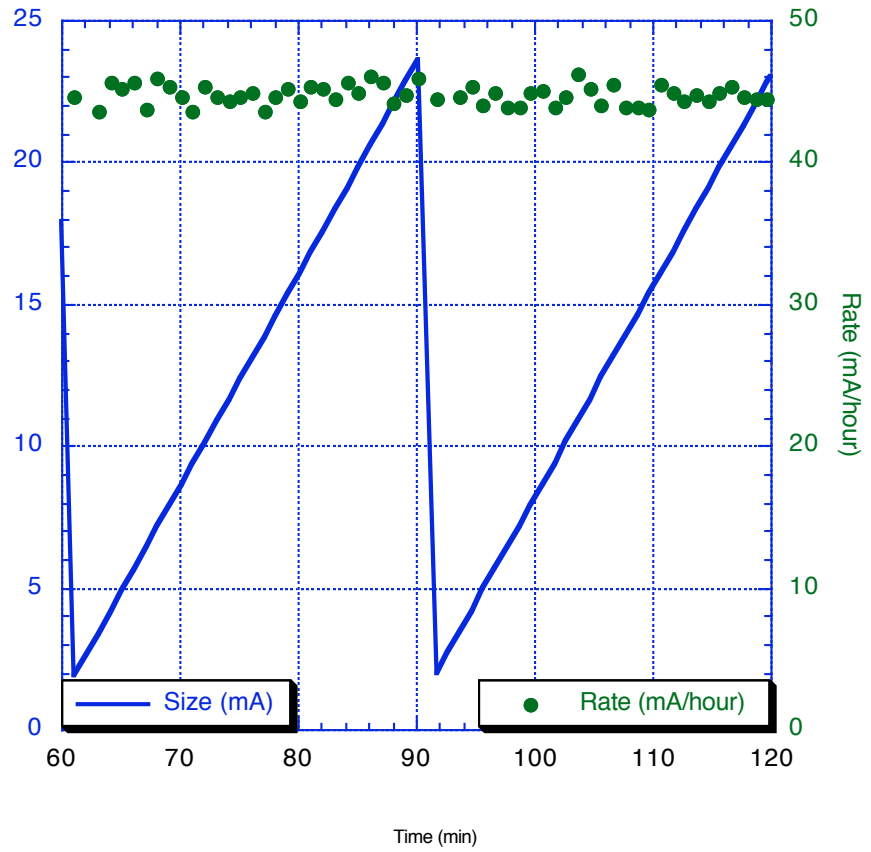


System Parameters

	2-4 GHz System (1/2 current system)	4-6 GHz System To be built
Pickup loops	160	320
Kicker Loops	128	256
Loop Impedance	20 □	5 □ (current) 10 □ (desired)
Front End Noise Temperature	125 K	125 K
Cryo Amps	8	8
1 Watt Amps	8	8
BAW Notch Filters	3	3
TWTs	20	20
TWT Power Supplies	20	20
Total Power	~500 W	~500 W

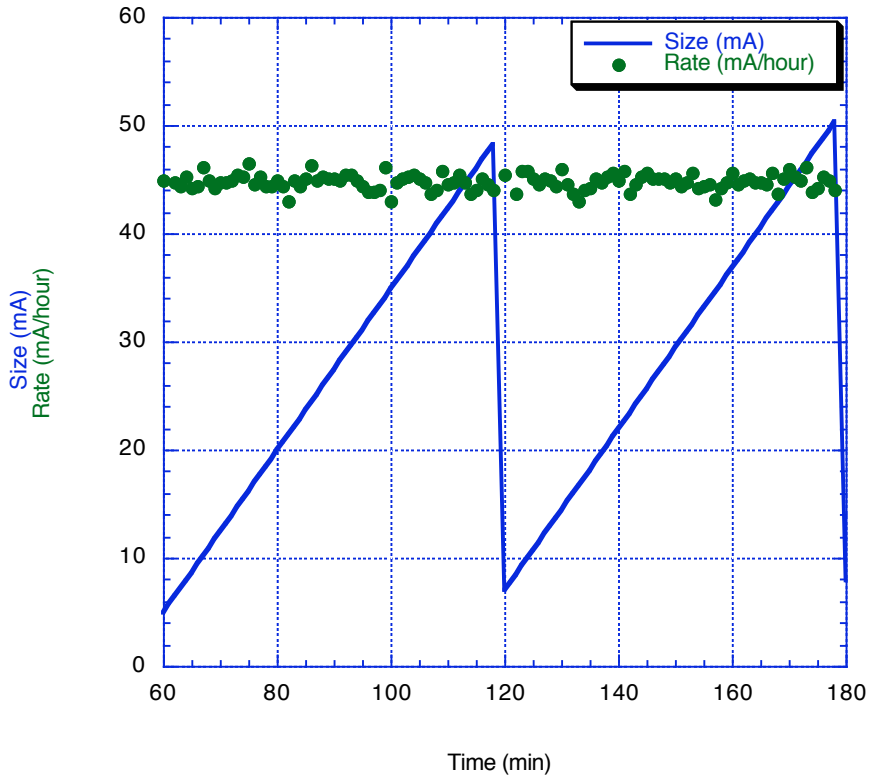
Results

- Time integration of Fokker-Planck equation, including feedback effects
- Sustains 45 mA/hour for 30 minutes
- Transfer ~22.5 mA every 30 minutes



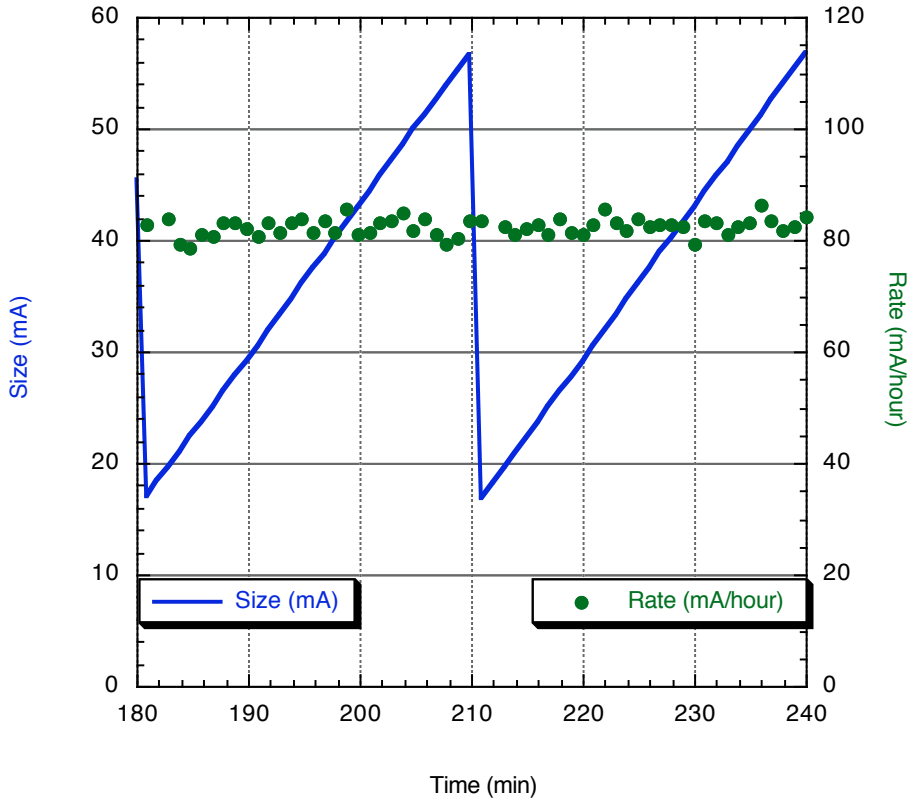
Results

- Time integration of Fokker-Planck equation, including feedback effects
- Sustains 45 mA/hour for 60 minutes
- Transfer ~45 mA every 60 minutes



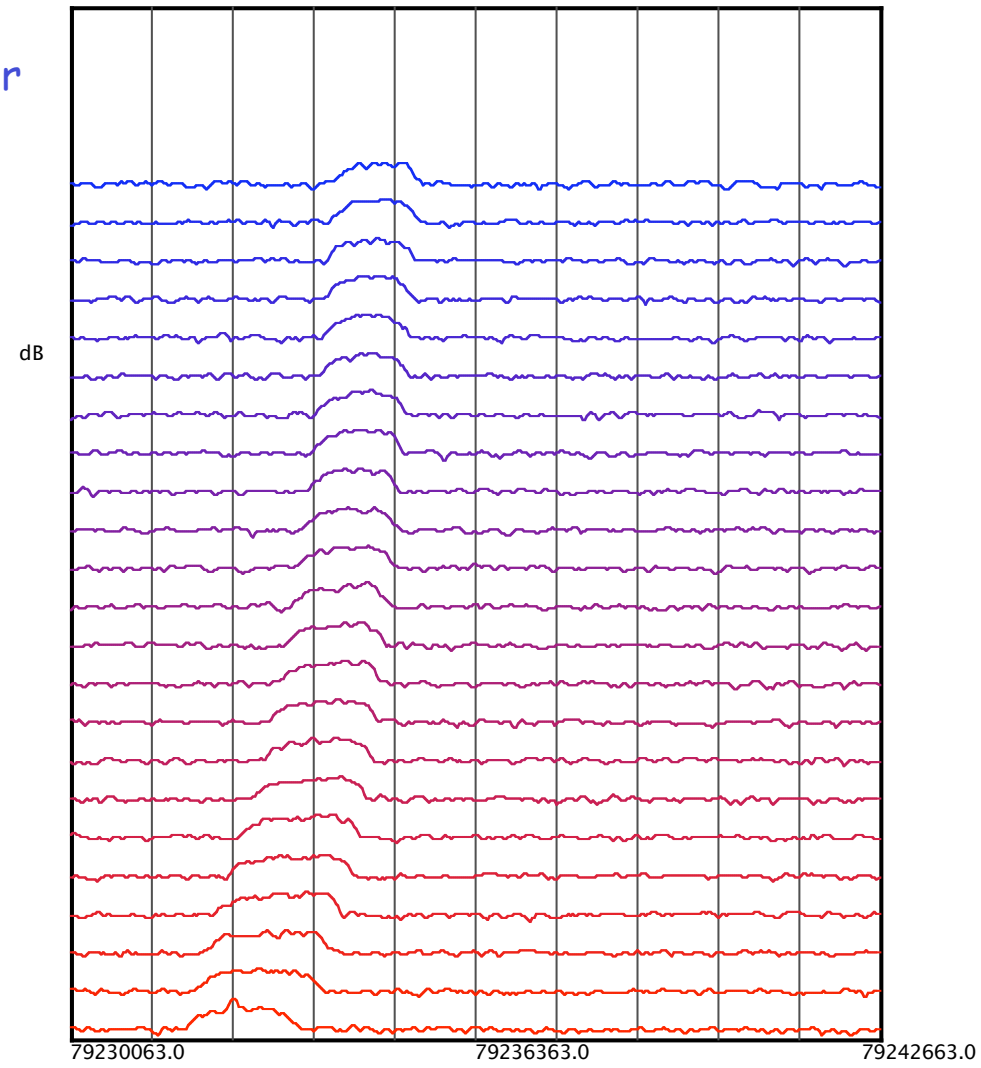
Results

- Time integration of Fokker-Planck equation, including feedback effects
- Sustains 80 mA/hour for 30 minutes
- Transfer ~40 mA every 30 minutes

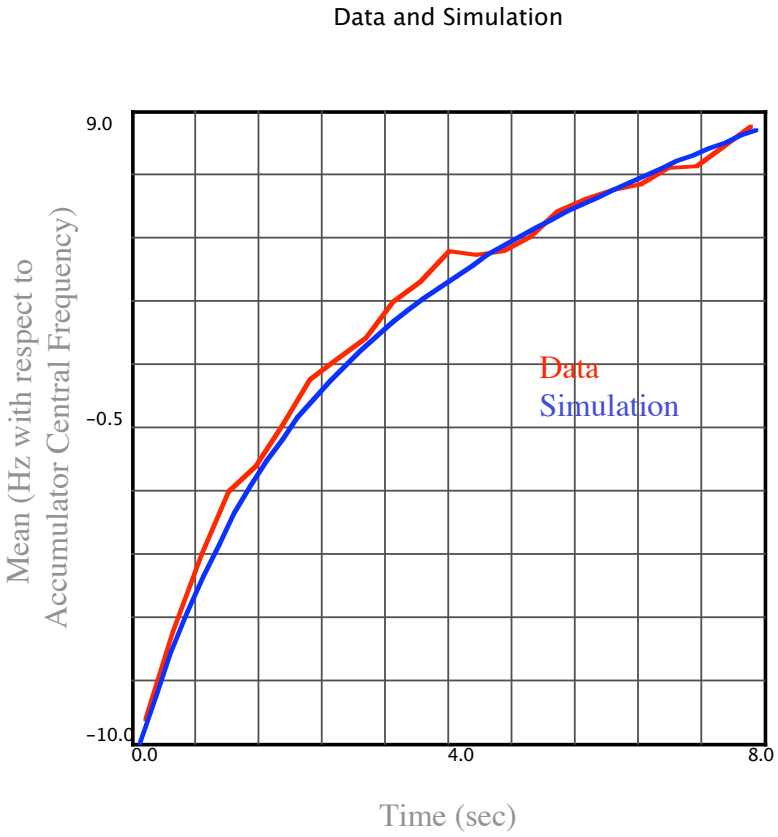


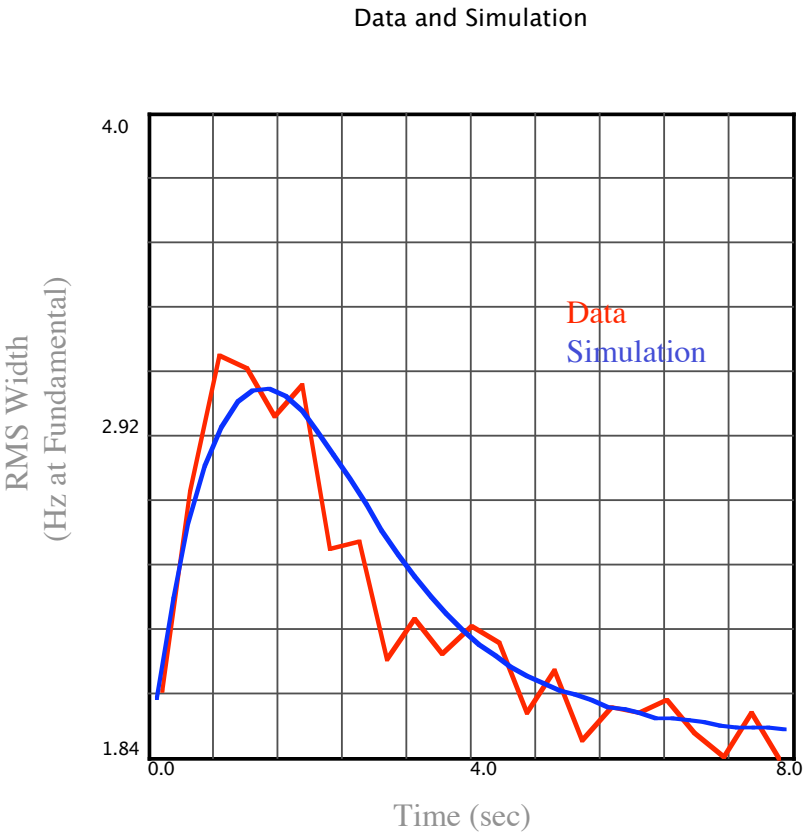
Simulation Tests

- Single Pulse Evolution
  - Single pulse into Accumulator
  - Using 79 MHz longitudinal Schottky, track evolution of the pulse
    - Motion of the mean
    - Change in the width
  - Direct Comparison of simulation and current stacktail
  - Key to future performance
    - How fast can move input pulse off deposition orbit



Pulse Evolution





Betatron System

- Calculations using current core betatron systems, including momentum distribution, give emittance ~10 π after 30 minutes
  - Reaches design specification
- But … a question of margin
  - Are there additional heating terms from stacktail not taken into account?
    - Not really understood in present system
      - Kicker asymmetries, momentum dispersion, etc.
  - A stacktail betatron system?
    - Modeled on Run I design: worked but not "effective"
      - no measurable impact on stacking rate
    - Use same pickups as used for momentum system
    - Kicker tanks in A20, both 2-4 and 4-6 GHz
    - Extra factor of ~3 in cooling performance

Schedule

- Stacktail Cooling: WBS 1.3.3.3
  - Momentum: WBS 1.3.3.3.1
    - Change the characteristic gain slope and increase the bandwidth of the stacktail momentum cooling system to handle input flux of greater than 40 mA/hour
    - Start Date: 1 March 03
    - Duration: 709 days
    - Cost Driver: TWTs and power supplies
    - Schedule Drivers: TWT Procurement, Installation (matching to shutdowns)
  - Betatron: WBS 1.3.3.3.2
    - Install a new stacktail betatron system to give additional transverse cooling during the stacking process. At this time, it is not clear whether such a system is required. The branch point to continue with this project is the system design milestone.
    - Start Date: 3 March 03
    - Duration: 709 Days
    - Schedule Drivers: TWT Procurement, Installation (matching to shutdowns)